



**HAL**  
open science

## Editorial: Advanced materials modeling combining model order reduction and data science

Chady Ghnatios, Anaïs Barasinski, Elias Cueto

### ► To cite this version:

Chady Ghnatios, Anaïs Barasinski, Elias Cueto. Editorial: Advanced materials modeling combining model order reduction and data science. *Frontiers in Materials*, 2023, 9, pp.1096233. 10.3389/fmats.2022.1096233 . hal-03977898

**HAL Id: hal-03977898**

**<https://univ-pau.hal.science/hal-03977898>**

Submitted on 7 Feb 2023

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



## OPEN ACCESS

EDITED AND REVIEWED BY  
Douglas Soares Galvao,  
State University of Campinas, Brazil

\*CORRESPONDENCE  
Chady Ghnatios,  
✉ chady.ghnatios@ensam.eu

SPECIALTY SECTION  
This article was submitted to  
Computational Materials Science, a  
section of the journal Frontiers in Materials

RECEIVED 11 November 2022  
ACCEPTED 28 December 2022  
PUBLISHED 11 January 2023

CITATION  
Ghnatios C, Barasinski A and Cueto E  
(2023), Editorial: Advanced materials  
modeling combining model order  
reduction and data science.  
*Front. Mater.* 9:1096233.  
doi: 10.3389/fmats.2022.1096233

COPYRIGHT  
© 2023 Ghnatios, Barasinski and Cueto.  
This is an open-access article distributed  
under the terms of the [Creative Commons  
Attribution License \(CC BY\)](https://creativecommons.org/licenses/by/4.0/). The use,  
distribution or reproduction in other  
forums is permitted, provided the original  
author(s) and the copyright owner(s) are  
credited and that the original publication in  
this journal is cited, in accordance with  
accepted academic practice. No use,  
distribution or reproduction is permitted  
which does not comply with these terms.

# Editorial: Advanced materials modeling combining model order reduction and data science

Chady Ghnatios<sup>1,2\*</sup>, Anais Barasinski<sup>3</sup> and Elias Cueto<sup>4</sup>

<sup>1</sup>PIMM Lab, Arts et Metiers Institute of Technologie, CNRS, HESAM University, 151 Boulevard de l'Hopital, Paris, France, <sup>2</sup>Department of Mechanical Engineering, Notre Dame university Louaizé, Keserwan, Lebanon, <sup>3</sup>Universite de Pau et des Pays de l'Adour, E2S UPPA, CNRS, IPREM, Pau, France, <sup>4</sup>Aragon Institute of Engineering Research, Universidad de Zaragoza, Zaragoza, Spain

## KEYWORDS

digital twins technologies, data-driven materials modeling, model reduction applications in materials forming, digital twins of materials and processes, machine learning of materials models

## Editorial on the Research Topic

[Advanced materials modeling combining model order reduction and data science](#)

Materials modeling has always been a challenging issue. Many complexities rise in such modelings, like non-linear material behavior, complex physics, and large deformation, coupled with multiphysics phenomena. Moreover, materials often exhibit rich behavior in response to thickness, hindering the use of classical simplifications, and imposing the need for an extremely refined mesh when using classical simulation techniques. Model reduction techniques appeared as a suitable solution to alleviate computational time. Many applications and material-forming processes benefit from the advantages offered by model reduction techniques including solid deformation, heat transfer, and fluid flow. Moreover, the recent development in data-driven modeling has opened novel possibilities in materials modeling. In fact, a correction or an update of the simulation using data modeling has led to the formation of the so-called “digital twin” models, improving the simulation with data-driven modeling. Data-driven modeling of materials for which current models are inaccurate also became possible through the use of machine learning algorithms.

The problem of efficiently building digital twins in the framework of materials manufacturing processes and materials modeling is thus, nowadays, a topic of increasing interest. Recent advances in digital twin technologies use experimental results to correct the simulation, but also to include their variability in the running simulation when a ground truth cannot be defined experimentally. This Research Topic addresses the recent developments in model reduction techniques, data-driven modeling, and digital twins technologies along with their applications in materials modeling and materials forming processes.

In [Victor Champany et al.](#), the authors tackle the problem of non-trivial interpolations, which arise, for example, when critical points in a curve, an elastic-plastic transition point, for instance, shifts location. To address an efficient solution to the problem, several methodologies are shown, coupling model reduction techniques and surrogate modeling. Moreover, surrogates that quantify and propagate uncertainties by delivering statistical bounds for the predicted curves are shown. Several applications are shown, featuring examples of classical mechanics of materials problems.

Optimization of scaffolds for tissue engineering, applied in bone regeneration problems, is tackled in [Muixí et al.](#) In this work, the authors use a coupled hyper-reduction technique and principal component analysis to create surrogate modeling of the designed scaffolds. Further, the surrogate modeling is leveraged in an inverse problem, thus identifying the process parameters and optimizing these parameters for the best scaffold material as desired outputs.

Since material observation is often partial, with partially observable data and expensive measurements which lead to data scarcity, data completion and modeling of partially observable data become a must, especially when manipulating data in the mechanics of materials. Therefore, in [Victor Champaney et al.](#), the authors tackle the modeling of partially observable data, using time evolution as the solution. In fact, taking into consideration previous input/output combinations would incorporate all the missing variables, or at least their effects, on the output. The problem is showcased in classical linear and non-linear Kelvin-Voight material models. On the other hand, data completion is tackled in [Aublet et al.](#), where an artificial intelligence-assisted data completion method is derived. The proposed data-augmentation technique is desirable for digital twinning assisted by artificial intelligence, especially when performing non-linear model reduction. The proposed method preserved similarities in terms of the validity domain of reduced digital twins. The method is leveraged to train a ROM-net with two showcased applications, one of them including a mechanical component undergoing cyclic loading at

high temperature, with the aim to characterize or predict its life expectancy.

## Author contributions

CG, AB, and EC contributed in writing the manuscript. CG wrote the first draft of the manuscript. CG, AB, and EC wrote different sections and reviewed the manuscript.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.